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PORTABLE AND COMPACT SURVEILLANCE ROBOT

The present application relates to a robotic structure. In particular, the application relates to a robotic structure
5 for climbing an object and to methods for ascending as well as for descending from the object.

Robots have automatically guided machines for performing pre-determined tasks. These robots can be used in a variety of
10 applications.

For instance, the robots can be deployed in civilian applications to inspect or search buildings with structural damages that are caused by earthquakes, floods, or hurricanes. The
15 robots can also be equipped with sensors for inspecting or searching buildings or outdoor sites that are contaminated with radiation, with biological agents such as viruses or bacteria, or with chemical spills.

20 Alternatively, the robots can be used in military applications that are deemed dangerous for soldiers. For instance, the robots can serve as scout units to survey enemy positions. The robots may also be used in law enforcement applications including reconnaissance, surveillance, bomb disposal,
25 al, and security patrols.

It is an object or purpose of the application to provide an improved robotic structure.

30 It is believed that a robot can have an improved structure. The robot is intended for performing certain task, such as surveillance. The improved structure has a movable base with two movable arms. Each arm comprises two links that are con-

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nected with a joint such that the arm is foldable. The arms can alter an inclination of the base by shifting weights or by changing positions of the arms.

- 5 Such improved structure has an advantage of being able climbing a solid object with a small frame. The arms can be reconfigurable easily for longer reach, if needed.

The application provides a robotic structure. The robotic
10 structure is designed to ascend and to descend from a solid object whilst having small dimensions. The object can include a step of a staircase.

The robotic structure includes a main body. The main body can
15 house a camera, an inertial sensor, and a control unit. For mobility purpose, a left main moving means is provided at a left side of the main body and a right main moving means is provided at a right side of the main body. The left and right main moving means are adapted or are configured to contact a
20 ground surface area on which the robotic structure is intended to move.

The robotic structure also includes one or more mechanical arm units. Each arm unit includes an upper branch member and
25 a lower branch member. A proximal end of the upper branch member is attached to the main body via an upper joint, which is usually located in the vicinity of a rear section of the main body. The upper branch member is rotatable about the upper joint via an upper actuator. In contrast, a proximal end
30 of the lower branch member is attached to a distal end of the upper branch member body via a lower joint. The lower branch member is rotatable about the lower joint via a lower actuator. The upper branch member further includes an auxiliary

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moving means, which is adapted to contact the ground surface area. The upper actuator and the lower actuator can include one or more motor units.

- 5 In a general sense, the arm unit can include more than two branch members. The lower branch member can also have an auxiliary moving means.

10 The main body and the arm units are provided such that in a climbing up or a climbing down position of the robotic structure the main body is supportable by a distal tip of the lower branch member and by the left main moving means or the right main moving means.

- 15 The above arm units have an advantage of allowing the robotic structure to ascend or to descend from a solid object with a small structure. This is unlike other implementations that require its main body to be large. In one example, a length of the main body is large such that the main body touches two
20 staircase steps for ascending the staircase steps.

In practice, the robotic structure can be placed in an ascending initial position in which the main body is rotated about the upper joint. A front section of the main body is
25 placed higher than the main body rear section, wherein the main body rear section and the auxiliary moving means contact the ground surface area to support the main body.

In addition, the robotic structure can be placed an operating
30 position in which front parts of the main moving means are contacting a solid object. The lower branch members are contacting the ground surface area to support the main body rear section whilst the upper branch members and the lower branch

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members are rotatable to change a height of the main body rear section.

A position and a weight of the upper branch members and of the lower branch members can be provided such that an orientation of the main body is alterable by shifting the position of the upper branch members and the lower branch members. The orientation of the main body includes an inclination of the main body. This shifting moves a centre of gravity of the upper branch members and of the lower branch members to generate a tilting moment for the main body. The tilting moment causes the main body to tilt or to rotate about an axis of the main body. This tilting is stopped when the lower branch members or the upper branch members touch the ground on which the main body rests. In other words, the ground stops the lower branch members or the upper branch members from moving which in turn causes the main body to stop tilting. This provides another means of changing the inclination of the main body.

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In operation, the robotic structure is usually provided with two arm units. A left arm unit is provided to the left side whilst a right arm unit is provided to the right side of the main body for lateral stability although other configurations are also possible. Whilst the subject matter of the application refers in general to two arm units, the application would also work with one single arm unit as long as the single arm unit is designed such that the robotic structure maintains lateral stability when using the single arm unit is used.

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The first member and the second member often have a general shape of an elongated strut or rod.

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The main moving means can include a set of wheels. The wheels can be arranged in one or two rows. The main moving means can also have a continuous track for easy movement over an uneven
5 ground.

In a similar manner, the auxiliary moving means can comprise one or more wheels. In a special case, the wheels turn freely without need for an actuator. Put differently, the wheels in-
10 clude freewheeling wheels. Such wheels are usually light and in turn allow the arm units to be light. The auxiliary moving means can also include a continuous track.

A tip area of the lower branch member can include a friction-
15 al surface to provide strong grip with an external surface.

Furthermore, the robotic structure can include a sensor, which often uses infrared, for determining a distance between the main body and a solid object that is in front of the main
20 body.

The robotic structure can have an inertial sensor for sensing a spatial orientation, which includes a direction and a tilt, of the main body. The direction and tilt information of the
25 main body are usually feedback to a control unit or a user of the robotic structure for controlling the robotic structure.

In addition, the robotic structure can include a camera that can tilt, rotate, or pan for providing video images of ob-
30 jects in the vicinity of the main body to the user or to the control unit for navigating the robotic structure.

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The robotic structure usually includes a control unit or a controller that is equipped with a program to control parts of the robotic structure. The control unit can communicate with a user of the robotic structure using a wireless means.

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Methods for a robotic structure to ascend and to descend from a solid object are provided below.

The application provides a method for a robotic structure to ascend a solid object.

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The robotic structure has a moving means as well as an arm unit. The arm unit comprises an upper branch member and a lower branch member. The main moving means is used for moving a main body of the robotic structure over a ground surface area. The upper branch member is pivotally attached to a rear section of the main body via an upper joint whilst the lower branch member is pivotally attached to the upper branch member via a lower joint. In a general sense, the robotic structure can have more than one moving means and more than one upper branch members that are connected to more than one lower branch members.

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The method comprises a step of tilting the main body by actuating the arm unit such that a front section of the main body is higher than a rear section of the main body. The actuation rotates the main body about the upper joint. The main body rear section and an auxiliary driving means of the upper branch member are contacting the ground surface area to support the main body. The tilted main body is positioned for ascending the object. The tilted main body is then positioned adjacent to the object by using the main moving means. The main body rear section is later elevated by actuating the arm

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unit such that the lower branch member contacts the ground surface area to support the rear section. The actuation also lifts the rear section of the main body. The elevated main body is afterward moved onto the object by using the main
5 moving means.

The step of tilting of the main body can include a step of determining a tilt angle of the main body to ensure that the main body is stable and that it does not topple.

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The application provides a further method for a robotic structure to ascend a solid object. The robotic structure is described above.

15 The method includes a step of the main body climbing up a part of the object such that a front section of the main body is elevated higher than its rear section. The rear section of the main body is then elevated by actuating the arm unit such that a tip of the lower branch member contacts the ground
20 surface area to support the rear section. The actuation also lifts the rear section of the main body. The elevated main body is afterward moved onto the object by using the main moving means.

25 The above step of climbing of the part of the object can include a step of determining a tilt angle of the main body to ensure that the main body is stable and that it does not topple. Similarly, the above step of the using of the moving means can include a step of determining a distance between
30 the main body and the object.

In addition, the above methods can include a step of shifting a position and a weight of the upper branch member and of the

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lower branch member to tilt the main body. The shifting of the position and a weight moves a centre of gravity of the lower branch member and the upper branch member to generate a rotating or tilting moment for the main body. The main body
5 is then tilted until the lower or the upper branch member is stopped from moving by the ground onto which the main body rests. This provides a simple means to tilt the main body.

The step of tilting the upper branch member and the step of
10 the tilting the lower branch member can include a step of determining a tilt angle of the main body.

The actuating of the arm unit can include a step of rotating the upper branch member about the upper joint or a step of
15 rotating the lower branch member about the lower joint. It can also include a step of rotating the upper branch member about the upper joint and of rotating the lower branch member about the lower joint.

20 The application provides a method for a robotic structure to descend from a solid object. The robotic structure is described above.

The method has a step of positioning the main body such that
25 a rear section of the main body protrudes from a side of the object by using the main moving means whilst the object supports the main body. A tip of the lower branch member then supports the rear section of the main body. This is achieved by actuating the arm unit such that a tip of the lower branch
30 member contacts a lower ground surface area to support the rear section. The main body is later moved away from the object by using the main moving means. After this, the rear section is lowered by actuating the arm unit. The main body

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is later moved further away from the object to lower a front section of the main body.

The step of positioning the main body can include a step of
5 determining a distance between the main body and a part of the object. Moreover, the step of lowering the main body rear section can include a step of determining a tilt angle of the main body.

10 The step of actuating the arm unit can include a step of rotating the upper branch member about the upper joint or a step of rotating the lower branch member about the lower joint. It can also include a step of rotating the upper
15 branch member about the upper joint and of rotating the lower branch member about the lower joint.

In the following description, details are provided to describe the embodiments of the application. It shall be apparent to one skilled in the art, however, that the embodiments
20 may be practised without such details.

Figs. below have similar parts. The similar parts have the same names or part numbers. The description of the similar parts is hereby incorporated by reference, where appropriate,
25 thereby reducing repetition of text without limiting the disclosure.

Fig. 1 illustrates a perspective view of an improved robot,
30 Fig. 2 illustrates a simplified side view of the improved robot of Fig. 1,
Fig. 2A illustrates a front view of the robot of Fig. 2,

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Fig. 3 illustrates an electrical functional blocks of the improved robot of Fig. 1,

Figs. 4 to 18 illustrates steps of ascending a staircase step using the improved robot of Fig. 1,

Fig. 4 illustrates a first step of ascending the staircase step,

Fig. 5 illustrates a second step of ascending the staircase step,

Fig. 6 illustrates a third step of ascending the staircase step,

Fig. 7 illustrates a fourth step of ascending the staircase step,

Fig. 8 illustrates a fifth step of ascending the staircase step,

Fig. 9 illustrates a sixth step of ascending the staircase step,

Fig. 10 illustrates a seventh step of ascending the staircase step,

Fig. 11 illustrates an eighth step of ascending the staircase step,

Fig. 12 illustrates a ninth step of ascending the staircase step,

Fig. 13 illustrates a tenth step of ascending the staircase step,

Fig. 14 illustrates an eleventh step of ascending the staircase step,

Fig. 15 illustrates a twelfth step of ascending the staircase step,

Fig. 16 illustrates a thirteen step of ascending the staircase step,

Fig. 17 illustrates a fourteen step of ascending the staircase step,

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Fig. 18 illustrates a fifteen step of ascending the staircase step,

Fig. 19 to 26 illustrates steps of descending from a staircase step using the improved robot of Fig. 1,

Fig. 19 illustrates a first step of descending from the staircase step,

Fig. 20 illustrates a second step of descending from the staircase step,

Fig. 21 illustrates a third step of descending from the staircase step,

Fig. 22 illustrates a fourth step of descending from the staircase step,

Fig. 23 illustrates a fifth step of descending from the staircase step,

Fig. 24 illustrates a sixth step of descending from the staircase step,

Fig. 25 illustrates a seventh step of descending from the staircase step,

Fig. 26 illustrates an eighth step of descending from the staircase step,

Fig. 27 illustrates method steps for ascending the staircase step,

Fig. 28 illustrates method steps for descending from the staircase step,

Fig. 29 to 36 illustrates further steps of ascending a staircase step using the improved robot of Fig. 1,

Fig. 29 illustrates a further first step of ascending the staircase step,

Fig. 30 illustrates a further second step of ascending the staircase step,

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Fig. 31 illustrates a further third step of ascending the staircase step,

Fig. 32 illustrates a further fourth step of ascending the staircase step,

5 Fig. 33 illustrates a further fifth step of ascending the staircase step,

Fig. 34 illustrates a further sixth step of ascending the staircase step,

10 Fig. 35 illustrates a further seventh step of ascending the staircase step,

Fig. 36 illustrates a further eighth step of ascending the staircase step, and

15 Fig. 37 illustrates a simplified side view of a further embodiment of the improved robot of Fig. 1

Fig. 1 shows an improved robot 10. The robot 10 has a base or main body 12. The main body 12 includes a controller and camera box 14 that is mounted on an upper surface of the main
20 body 12. The main body 12 also comprises a pair of moving means 16 and 17 as well as a pair of an improved arm 20.

The moving means 16 and one arm 20 are attached to one side of the main body 12 whilst another moving means 17 and another
25 arm 20 are attached to one side of the main body 12. Each movement means 16 or 17 includes a continuous track 19.

As better seen in Fig. 2, the continuous tracks 19 extend from a front-end 22 to a rear-end 23 of the main body 12. The
30 main body 12 has track-driving pulleys, which engages with the continuous tracks 19. The track-driving pulleys are not shown in Fig. 2.

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Each arm 20 includes a first link 25 and a second link 26. The first link 25 is also called an upper link whilst the second link 26 is also called a lower link.

5 Referring to the first links 25, they have first ends 28 that attach to the main body rear-end 23 by body rotational joints 30 such that the first links 25 can rotate freely around the body rotational joints 30. The main body 12 also includes a link driving mechanism to position the first links 25 at different angles to the main body 12. The link driving mechanism is not shown in Fig. 2. The first links 25 also have second ends 34.

15 Similarly, the second links 26 have first ends 32 that attach to the second ends 34 of the first links 25 by link rotational joints 36, which enables the second links 26 to rotate freely about the link rotational joints 36. The link driving mechanism is also used to position the second links 26 at different angles to the first links 25. The second ends 34 of the first links 25 have supporting wheels 38. Each second end 20 40 of the second link 26 has a pair of claws 42, as illustrated in Fig. 1.

The controller and camera box 14 includes a camera and an inertial sensor, both of which are not shown in Fig. 1. The camera is moveable in that it can tilt and rotate. The inertial sensor is positioned at centre of gravity within the main body 12 for easier sensing. A front part of the main body 12 has a distance-measuring sensor 41, as illustrated in 30 Fig. 2A.

The main body also has electrical functional blocks, which are shown in Fig. 3. The electrical functional blocks include

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an onboard control module 45 that is electrically connected to a communication device 46 and that is electrically connected to a drive control module 47. The communication device 46 is communicatively connected to a remote control module 49 via a wireless medium.

In a generic sense, the tracks 19 can be replaced by a row of wheels.

The first links 25 and the second links 26 do not have a track or wheel mechanism, which is an advantage as they can then have a lightweight. This is unlike other implementations that connect a track and a track flipper to each side of a chassis.

The robot 10 can fit into a box having dimensions of 305 millimetres by 240 millimetres by 180 millimetres. This is unlike other robot that performs the similar functions and that have dimensions of more than 1 meter.

Functionally, the robot 10 is used for climbing or ascending a solid object, such as a step of a staircase, and for descending from the object.

The robot 10 has the improved arms 20 for lowering or lifting the rear-end 23 of the main body 12. The arms 20 can also be used in combination with the tracks 19 to lower or to raise the front-end 22 of the main body 12. The arms 20 can also be used to clear obstacles and to grip objects.

A user can use the remote control module 49 to receive data from the robot 10 and to transmit instructions or control signals to the robot 10 via the communication device 46.

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The inertial sensor senses a tilt as well as a planar orientation of the main body 12. The tilt relates to an angle of the main body to a flat ground area whilst the orientation
5 relates to a direction of the main body 12. The inertial sensor also detects a yaw or a deviation from intended movement of the main body 12. The inertial sensor also sends the tilt, orientation, and yaw information to the onboard control module 45.

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As illustrated in Fig. 2, the camera has a field of view 50. The camera can tilt or rotate to provide images around the main body 12 in its field of view 50 for a user of the robot 10. The sensor 41 uses infrared to measure a distance between
15 the main body 12 and a solid object that is placed in front of the robot 10.

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The onboard control module 45 is equipped with programs or software for ascending an object and for descending from the object. The onboard control module 45 receives sensed tilt and orientation information from the inertial sensor and receives object distance information from the distance-measuring sensor 41. The onboard control module 45 uses the received information to determine drive control information,
25 which are transmitting to the drive control module 47. The onboard control module 45 also receives yaw information from the inertial sensor, which is used to correct the main body movement.

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The drive control module 47 used the received control information to drive motor for turning the track driving pulleys to move the continuous tracks 19. The received control information is also used to adjust the link driving mechanism for

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positioning the first link 25 at a desired angle to the main body 12 and for positioning the second link 26 at a desired angle to the first link 25.

- 5 The motor also provides feedback to the onboard control module 45, which is used to indicate that the main body 12 is touching an obstacle that is preventing the main body 12 from advancing.
- 10 The tracks 19 are used for engaging the ground that is beneath the main body 12 for moving the main body 12 forward or backward. The tracks 19 allow the robot 10 to manoeuvre in uneven terrain. In certain situations, the tracks 19 have cleats for better traction or soft plates that are connected
- 15 to outer surface of the tracks 19 for protecting the ground over which the tracks 19 move.

The arms 20 is used for lifting or lowering the rear-end 23 of the main body 12. By changing the positions of the first

20 links 25 with respect to the main body 12 and by changing the positions of the second links 26 with respect to the first links 25, the arms 20 is able to elevate or lower the rear-end 23. When the arms 20 support the rear-end 23 of the main body 12, the tracks 19 can be used to lower or raise the

25 front-end 22 of the main body 12.

The arms 20 have an advantage of flexible use and yet can have a lightweight structure.

- 30 The supporting wheels 38 allow the main body 12 to move when the wheels 38 are supporting the weight of the main body 12 during certain steps of ascending an obstacle, such as a staircase step, or of descending from the obstacle.

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The claws 42 of the second links 26 are also used for engaging the ground during certain robot ascending or descending sequences. The claw 42 can also be used for gripping, pushing, or pulling objects.

A method of ascending a staircase step 52 using the robot 10 is described below.

10 The robot 10 is positioned on a ground 57 and is in an initial mode or position, as illustrated in Fig. 4. In this mode, the arms 20 are folded or retracted. Put differently, the first links 25 are positioned parallel to the main body 12 and has an angle of zero degrees to the main body 12. The
15 second links 26 also have an angle of zero degrees to the first links 25.

The staircase step 52 includes a riser 54 and a tread 56 that is connected to the riser 54. The riser 54 relates to a vertical part of the staircase step 52 whilst the tread 56 relates to a horizontal part of the staircase step 52.

The method includes a body front-end tilting sequence 60 or step, which is followed by a body rear-end tilting step 62, as illustrated in Fig. 27. A body positioning 63 step follows the body rear-end tilting step 62.

In the body front-end tilting step 60, the front-end 22 of the main body 12 is elevated above the ground 57 whilst the
30 rear-end 23 of the main body 12 remains in contact with the ground 57.

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In this tilting step 60, the onboard control module 45 controls the tracks 19 to approach the staircase step 52. When the distance-measuring sensor 41 senses that the main body 12 is about 200 millimetres from the staircase step 52, the
5 onboard control module 45 rotates the first links 25 such that the main body front-end 22 elevate from the ground 57 whilst the main body rear-end 23 remains in contact with the ground 57. The second links 26 have an angle of zero degrees with the first links 25. The elevating of the front-end 22
10 continues until the main body 12 inclines or tilts at about 45 degrees to the ground 57, as sensed by the inertial sensor. This is illustrated in Fig. 5.

The elevating of the front-end 22 then ceases. The tracks 19
15 later turn to move the main body 12 towards the staircase step 52 until the front-end 22 touches the riser 54, as illustrated in Fig. 6. The supporting wheels 38 support the main body 12 and enable the arms 20 to move towards the staircase step 52. The touching is detected by a feedback
20 from the motor that drives the track driving pulleys to move the tracks 19.

The onboard control module 45 later causes the robot 10 to return to the initial mode whilst its main body 12 maintains
25 its tilt angle of about 45 degrees to the ground 57. For returning to the initial mode, the first links 25 are positioned at an angle of zero degrees to the main body 12 whilst the second links 26 have an angle of zero degrees with the first links 25. This is illustrated in Fig. 7.

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The tracks 19 later turn to increase the incline of the main body 12. The incline is maintained at less than 90 degrees and such that the main body 12 does not topple over, as il-

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illustrated in Fig. 8. The onboard control module 45 also checks the distance between the main body 12 and the object that is in front of the main body 12 using the distance-measuring sensor 41. The increase of incline of the main body
5 12 stops when the said distance is more than 100 millimetres and when the tilt angle is between 70 and 90 degrees.

In the body rear-end tilting step 62, the rear-end 23 of the main body 12 is lifted up until it is at about the same level
10 as the front-end 22 of the main body 12. The front-end 22 is positioned over the staircase step 52.

In this tilting step 62, the first links 25 rotate away from the staircase step 52 until the first links 25 have an angle
15 of about 100 to 120 degrees with the main body 12 whilst the second links 26 maintain a zero degrees angle with the first links 25. The tracks 19 do not turn with relative to the main body 12. This is illustrated in Fig. 10. This movement positions the main body 12 for lifting the rear-end 23 of the
20 main body 12.

The second links 26 then rotates such that the angle between the first links 25 and the second links 26 increases. This rotation lifts up the rear-end 23 of the main body 12, as il-
25 lustrated in Fig. 11.

After this, the second links 26 continues to rotate until the angle between the first links 25 and the second links 26 reaches approximately between 60 to 80 degrees, as illustrat-
30 ed in Fig. 12. This rotation lifts the rear-end 23 higher. The second links 26 then cease rotating.

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The first links 25 afterward rotates further by about 10 to 20 degrees to lift the rear-end 23 higher, as illustrated in Figs. 13 and 14. Following this, the first links 25 stop rotating. The first links 25 and the second links 26 then support the main body 12.

In a special embodiment, the second links 26 has wheels to facilitate its movement on the ground whilst they support the main body 12. In one example of the special embodiment, the second links 26 have each three more wheels whilst the first links 25 have each one or more wheels 38.

In the body positioning step 63, the main body 12 moves forward over the tread 56 till the rear-end 23 of the main body 12 is above the tread 56 and it does not overhang or stick out over the ground 57.

In this positioning step 63, the tracks 19 turn to move the main body 12 forward and over the tread 56 as well as towards the next riser. The tracks 19 stop turning when the main body 12 travels about 90% to 95% of the tread 56, as determined by the distance-measuring sensor 41. This is illustrated in Fig. 15. The tracks 19 also turn in such a way as to adjust orientation of the main body 12, as sensed by its inertial sensor. The adjustment can straighten the main body 12, if the main body 12 is slanted.

The onboard control module 45 then retracts the arms 20, as illustrated in Fig. 16. The retraction, as illustrated in Figs. 17 to 18, causes the robot 10 to return to its initial mode. The first links 25 are rotated such that they have an angle of zero degrees with the main body 12 whilst the second

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links 26 are rotated such that they have angle of zero degrees with the first links 25.

The robot 10 has now ascended the staircase step 52.

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A method of descending from the staircase step 52 using the robot 10 is described below.

10 The robot 10 is positioned on the tread 56 of the staircase step 52 and is in the initial mode as described above.

15 The method includes a body positioning step 65, which is followed by a body rear-end tilting step 67. The body rear-end tilting step 67 is followed by a body front-end tilting step 68.

20 In the body positioning step 65, the rear-end 23 of the main body 12 is positioned such that it stick out of the staircase step 52 and it overhangs the ground 57. The front-end 22 of the main body 12 is in contact with the tread 56.

25 This positioning is achieved by sensing the distance between the robot 10 and an end part of the riser 54 or by sensing the distance between the robot 10 and an end part of the tread 56. In this case, this distance is about 100 to 200 millimetres. The inertia sensor also verifies that the robot 10 is straight in that it is essentially perpendicular to an edge of the staircase step 52.

30 For this positioning step 65, the tracks 19 turns such that the rear-end 23 of the main body 12 overhangs over the ground 57, as illustrated in Fig. 19

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In the body rear-end tilting step 67, the rear-end 23 is tilted downwards or is lowered whilst the front-end 22 of the main body 12 remains in contact with the tread 56.

- 5 For this tilting step 67, the first links 25 rotate such that its second ends 34 are lifted up whilst the second links 26 maintain an angle of zero degrees with the first links 25, as illustrated in Fig. 20.
- 10 Later, the first links 25 continues its rotation whilst the second ends 40 of the second links 26 rotate away from the main body 12, as illustrated in Fig. 21.

The rotation continues such that the second ends 40 of the
15 second links 26 reach a joint between the riser 54 and the ground 57 or such that the angle between the first links 25 and the second links 26 approaches or is about 225 degrees. This is illustrated in Fig. 22.

- 20 Fig. 22 shows the second ends 40 touching the ground 57 and being positioned nearest possible the main body 12, although other positions are also possible. For example, the second ends 40 can be touching the ground 57 and being positioned furthest possible from the main body 12.

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In one embodiment of Fig. 22, the second links 26 have wheels to facilitate movement of the main body 12 away from the riser 54. They each can have two or more such wheels whilst the first links 25 each can have one or more wheels 38.

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The tracks 19 then turns such that the rear-end 23 of the main body 12 moves away from the riser 54. The second links 26 then rotate in a manner that causes the rear-end 23 of the

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main body 12 to descend, as illustrated in Fig. 23. The first links 25 and the second links 26 rotate such that the link rotational joints 36 are positioned away from the riser 54.

5 In another example, which is not illustrated in the Figs, the first links 25 and the second links 26 can also rotate such that the link rotational joints 36 are positioned toward, instead of away, from the riser 54.

10 In the body front-end tilting step 68, the front-end 22 of the main body 12 is lowered to the ground 57.

For this tilting step 68, the first links 25 and the second links 26 also rotate further and the tracks 19 such that the
15 front-end 22 of the main body 12 descend to the ground 57. Furthermore, the first links 25 later have an angle of zero degrees with the second links 26, as illustrated in Fig. 24.

After this, the robot 10 returns to its initial mode. The
20 first links 25 rotate such that its ends 34 move towards the main body 12, as illustrated in Fig. 25. The first links 25 later forms an angle of zero degrees with the main body 12 whilst the second links 26 form an angle of zero degrees with the first links 25, as illustrated in Fig. 26.

25 The robotic 10 has now descended from the staircase step 52.

In a generic sense, the above method steps for ascending or descending from the staircase step 52 can be used for ascend-
30 ing or descending from other objects.

A further method of ascending from the staircase step 52 using the robot 10 is described below.

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The robot 10 is positioned on a ground 57 and is in an initial mode, as described above and as illustrated in Fig. 29. In this mode, the arms 20 are folded.

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The distance-measuring sensor 41 of the main body 12 determines the height of the staircase step 52. Using the height information, the onboard control module 45 then controls the tracks 19 to approach the staircase step 52. The tracks 19 later climb the riser 54 until the main body 12 is at an incline of about 45 degrees, as illustrated in Fig. 30. The inertial sensor detects the incline angle.

The arms 20 later unfold. The first links 25 rotate away from the riser 54 whilst the second links 26 also rotate away from the riser 54, as illustrated in Fig. 31. The rotation of the first links 25 and the second links 26 also change a position of a centre of the gravity of the first links 25 and the second links 26.

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The first links 25 and the second links 26 rotate away from the riser 54 until the position and the weight of the first links 25 and the second links 26 causes the main body 12 to shift or to tilt further upwards, as illustrated in Fig. 32, until ends of the second links 26 contact with the ground 57. Put differently, the shifting of the position of the first links 25 and the second links 26 allows the weight of the first links 25 and the second links to move a centre of gravity of the first links 25 and the second links 26 to generate a turning moment for the main body 12. This turning moment causes the main body 12 to rotate or tilt about an axis of the main body that passed through a surface area of the main body 12 that contacts with the ground 57. The tilting stops

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when this the second links 26 touches the ground 57. Put differently, the ground 57 stops the second links 26 from moving.

- 5 This changing of the position of the first links 25 and the second links 26 has an advantage of allowing a simple way of tilting the main body 12 upright or upward.

After this, the tilted main body 12 moves toward the riser
10 54, as illustrated in Fig. 33. The first links 25 and the second links 26 then rotate to lift the rear end 23, as illustrated in Fig. 34 and then lift the rear end 23 higher, as illustrated in Fig. 35. Ends of the second links 26 contact the ground 57 at an area or a point that is far or furthest
15 from the riser 54.

During the lifting of the rear end 23, the tracks 19 may turn to bring the front-end 22 further over the tread 56 and away from the riser 54. The first links 25 and the second links 26
20 afterward turn to fold the arms 20, as illustrated in Fig. 36.

A different embodiment of the robot 10 of Fig. 1 is possible. Fig. 37 shows one possible embodiment of the robot 10. Fig.
25 37 depicts a robot 70, which includes above described parts of the robot 10 of Fig. 2.

The second links 26 of the robot 70 has the second ends 40, which have supporting wheels 39. Other ends 112 of the second
30 links 26 also have supporting wheels 110, as illustrated in Fig. 37. The supporting wheels 39, 110, or both 39 and 110 allow the main body 12 to move when the wheels 39, 110, or both 39 and 110 are supporting the weight of the main body

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during certain steps of ascending an obstacle, such as a staircase step, or of descending from the obstacle.

In one implementation, each second link 26 has three or more supporting wheels 39 to facilitate movement on the ground. In another implementation, the second link 26 has two or more freewheeling wheels 39 whilst the first link 25 has one or more supporting wheel 38. The arm 20 has three or more supporting wheels. The freewheeling wheels 39 are light and do not add much weight to the arm 20.

The first link 25 is connected to a motor 100 for rotating the first link 25 about the link rotational joint 78. A motor arrow 102 indicates one possible direction of rotation of the motor 100. The motor 100 can rotate the first link 25 in a clockwise direction as well as in an anti-clockwise direction. Similarly, the second link 26 is connected to motors 104 and 105 for rotating the second link 26 about the link rotational joint 36. Motor arrows 107 and 109 indicate possible directions of rotation of the motors 104 and 105 respectively. The motors 104 and 105 can rotate the second link 26 in a clockwise direction as well as in an anti-clockwise direction.

The tracks 19 are connected to and are driven by wheels 72, as shown in Fig. 37. In a special case, the robot 70 does not have the tracks 19 and have just the wheels 72. Moreover, the controller and camera box 14 has a tilt sensor 74, as shown in Fig. 37. The main body 12 has an inertia sensor 103. In certain implementations, the inertia sensor 103 includes the tilt sensor 74.

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Although the above description contains much specificity,
this should not be construed as limiting the scope of the em-
bodiments but merely providing illustration of the foreseea-
ble embodiments. The above stated advantages of the embodi-
5 ments should not be construed especially as limiting the
scope of the embodiments but merely to explain possible
achievements if the described embodiments are put into prac-
tise. Thus, the scope of the embodiments should be determined
by the claims and their equivalents, rather than by the exam-
10 ples given.

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Reference

	10	robot
	12	main body
5	14	controller and camera box
	16	moving means
	17	moving means
	19	track
	20	arm
10	22	front-end
	23	rear-end
	25	first link
	26	second link
	28	first end
15	30	body rotational joint
	32	first end
	34	second end
	36	link rotational joint
	38	supporting wheel
20	39	supporting wheel
	40	second end
	41	front sensor
	42	claw
	45	onboard control module
25	46	communication device
	47	drive control module
	49	remote control module
	50	field of view
	52	step
30	54	riser
	56	tread
	57	ground
	60	step

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	62	step
	63	step
	65	step
	67	step
5	68	step
	70	robot
	72	wheels
	74	tilt sensor
	103	inertial sensor
10	100	motor 100
	102	motor
	104	motor
	105	motor
	107	motor arrow
15	109	motor arrow
	110	wheel
	112	end

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CLAIMS

1. A robotic structure (12, 16, 17, 20) comprising
a main body (12) with a left main moving means (16)
5 being provided at a left side of the main body (12) and
with a right main moving means (17) being provided at a
right side of the main body (12), the left and right
main moving means (16, 17) being adapted to contact a
ground surface area (57) on which the robotic structure
10 (12, 16, 17, 20) is intended to move, and with at least
one arm unit (20) that comprises the following elements:
- an upper branch member (25) being attached to
the main body (12) via an upper joint (30) and be-
ing rotatable about the upper joint (30) via an up-
15 per actuator (104, 105),
- a lower branch member (26), a proximal end of
the lower branch member (26) being attached to the
upper branch member (25) via a lower joint (36) and
being rotatable about the lower joint (36) via a
20 lower actuator (100),
wherein the upper branch member (25) further com-
prises an auxiliary moving means (38), the auxilia-
ry moving means (38) being adapted to contact the
ground surface area (57),
25 wherein the main body (12) and the arm unit (20) are
provided such that in a climbing position of the robotic
structure (12, 16, 17, 20), the main body (12) is sup-
portable by a distal tip (40) of the lower branch member
(26) and by at least one of the left main moving means
30 (16) and the right main moving means (17).
2. A robotic structure (12, 16, 17, 20) of claim 1, wherein

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a position and a weight of the upper branch member (25) and the lower branch member (26) are provided such that an orientation of the main body (12) is alterable by shifting the position of the upper branch member (25) and the lower branch member (26).

3. A robotic structure (12, 16, 17, 20) of claim 1 or 2, wherein two arm units (20) are provided, a left arm unit (20) being provided at the left side and a right arm unit (20) being provided at the right side of the main body (12).
4. A robotic structure (12, 16, 17, 20) of one of claims 1 to 3, wherein the main moving means (16, 17) comprises a set of wheels (72).
5. A robotic structure (12, 16, 17, 20) of one of claims 1 to 3, wherein the main moving means (16, 17) comprises a track (19).
6. A robotic structure (12, 16, 17, 20) of one of claims 1 to 5, wherein the auxiliary moving means comprises at least one free-wheeling wheel (38).
7. A robotic structure (12, 16, 17, 20) of one of claims 1 to 5, wherein the auxiliary moving means (38) comprises a track (19).
8. A robotic structure (12, 16, 17, 20) of one of claims 1 to 7, wherein

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a tip area of the lower branch member (26) comprises a frictional surface.

9. A robotic structure (12, 16, 17, 20) of one of claims 1
5 to 8 further comprising
a sensor (41) for determining a distance between the
main body (12) and an object (52).
10. A robotic structure (12, 16, 17, 20) of one of claims 1
10 to 9 further comprising
an inertial sensor (74) for sensing a spatial orientation of the main body (12).
11. A robotic structure (12, 16, 17, 20) of one of claims 1
15 to 10 further comprising
a camera (14) for providing images of an object (52) in
the vicinity of the main body (12).
12. A method for a robotic structure (12, 16, 17, 20) to ascend an object (52), the robotic structure (12, 16, 17,
20) comprising
- a main moving means (16, 17) for moving a main body (12) of the robotic structure (12, 16, 17, 20) over a ground surface area (57) and
 - 25 - an arm unit (20) comprising an upper branch member (25) and a lower branch member (26),
the upper branch member (25) being pivotally attached to a main body (12) via an upper joint (30) and the lower branch member (26)
30 being pivotally attached to the upper branch member (25) via a lower joint (36),
the method comprising

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tilting the main body (12) by actuating the arm unit (20) such that a front section (22) of the main body (12) is higher than a rear section (23) of the main body (12),

5 positioning the main body (12) adjacent to the object (52) by using the main moving means (16, 17),

elevating the rear section (23) by actuating the arm unit (20) such that the lower branch member (26) contacts the ground surface area (57) to support the rear section (23), wherein the actuation also lifts the rear section (23), and

moving the main body (12) onto the object (52) by using the main moving means (16, 17).

15 13. A method of claim 12, wherein the tilting of the main body (12) comprises determining a tilt angle of the main body (12).

14. A method for a robotic structure (12, 16, 17, 20) to ascend an object (52), the robotic structure (12, 16, 17, 20) comprising

- a main moving means (16, 17) for moving a main body (12) of the robotic structure (12, 16, 17, 20) over a ground surface area (57) and
- 25 - an arm unit (20) comprising an upper branch member (25) and a lower branch member (26), the upper branch member (25) being pivotally attached to the main body (12) via an upper joint (30) and the lower branch member (26) being pivotally attached to the upper branch member (25) via a lower joint (36),

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the method comprising

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the main body (12) climbing a part of the object (52),

elevating a rear section (23) of the main body (12) by actuating the arm unit (20) such that the lower branch member (26) contacts the ground surface area (57) to support the rear section (23), wherein the actuation also lifts the rear section (23), and

moving the main body (12) onto the object (52) by using the main moving means (16, 17).

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15. A method of claim 14, wherein the climbing of the part of the object (52) comprises determining a tilt angle of the main body (12).

15 16. A method of one of claims 12 to 15, wherein the using of the main moving means (16, 17) comprises determining a distance between the main body (12) and the object (52).

20 17. A method of one of claims 12 to 16 further comprising shifting a position and a weight of the upper branch member (25) and of the lower branch member (26) to tilt the main body (12).

25 18. A method of one of claims 12 to 17, wherein the actuating of the arm unit (20) comprises determining a tilt angle of the main body (12).

19. A method of one of claims 12 to 18, wherein the actuating of the arm unit (20) comprises rotating the upper branch member (25) about the upper joint (30).

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20. A method of one of claims 12 to 19, wherein

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the actuating of the arm unit (20) comprises rotating the lower branch member (26) about the lower joint (36).

21. A method for a robotic structure (12, 16, 17, 20) to descend from an object (52), the robotic structure (12, 16, 17, 20) comprising
- a main moving means (16, 17) and
 - an arm unit (unit) comprising an upper branch member (25) and a lower branch member (26), the upper branch member (25) being pivotally attached to a main body (12) of the robotic structure (12, 16, 17, 20) via an upper joint (30) and the lower branch member (26) being pivotally attached to the upper branch member (25) via a lower joint (36),
- the method comprising
- positioning the main body (12) such that a rear section (23) of the main body (12) protrudes from a side of the object (52) by using the main moving means (16, 17),
 - supporting the rear section (23) by actuating the arm unit (20) such that the lower branch member (26) contact a lower ground surface area (57),
 - moving the main body (12) away from the object (52) by using the main moving means (16, 17),
 - lowering the rear section (23) by actuating the arm unit (20), and
 - moving the main body (12) away from the object (52) to lower a front section (22) of the main body (12).
22. A method of claim 21, wherein

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the positioning of the main body (12) comprises determining a distance between the main body (12) and the object (52).

- 5 23. A method of claim 21 or 22, wherein
the lowering of the rear section (23) comprises determining a tilt angle of the main body (12).
24. A method of one of claims 21 to 23, wherein
10 the actuating of the arm unit (20) comprises determining a tilt angle of the main body (12).
25. A method of one of claims 21 to 24, wherein
the actuating of the arm unit (20) comprises rotating
15 the upper branch member (25) about the upper joint (30).
26. A method of one of claims 21 to 25, wherein
the actuating of the arm unit (20) comprises rotating
the lower branch member (26) about the lower joint (36).